REMARKS

Claims 1-3 are pending in the present application. Claim 1 is herein amended. Claim 4 is cancelled.

Claim Rejections

Claims 1-4 were rejected under 35 U.S.C. § 103(a) as being unpatentable over **Ranta**, *Carbon Nanotube Reinforcement of a Filament Winding Resin*, 47th International SAMPE Symposium, May 12-16, 2002, pp. 1775-1787 (disclosed in the IDS filed August 20, 2003; "*Ranta*") in view of ***Yanagisawa*** (U.S. Patent 6,654,229). Favorable reconsideration is requested.

A. Impregnated into the Fiber Reinforcement

Applicants respectfully submit that Ranta does not disclose "a matrix that comprises an uncured resin and carbon nanofibers dispersed in said uncured resin and is ***impregnated*** into said fiber reinforcement" as recited in claim 1.

Ranta discloses that a carbon nanotube reinforced epoxy is used in filament winding. (Ranta, at 1775.) The filament wound composite material has a different structure than a composite material in which the matrix is impregnated into the fiber reinforcement. The present invention as recited in claim 1 requires that the matrix is impregnated into the fiber reinforcement. Therefore, Ranta does not disclose the elements as recited in claim 1.

B. No Motivation to Combine the References

Applicants respectfully submit that one of ordinary skill in the art at the time of the invention would not have been motivated to combine the teachings of Yanagisawa with the teachings of Ranta.

Ranta discloses a carbon nanotube reinforced epoxy. *Ranta* states:

> the objective of this study is to develop a method to reinforce epoxy with nanotubes, and to use nano-reinforced epoxy to wet wind carbon fiber composites.

(*Ranta*, p. 1776.)

Yanagisawa discloses an electrode material for an electric double layer capacitor having a carbon fiber as an essential material. The carbon fiber has a coaxial stacking morphology of truncated conical tubular graphene layers. The carbon fiber is disclosed as increasing electrical capacitance of the electrode material. Yanagisawa does not disclose that the carbon fiber having a coaxial stacking morphology might be applied to a fiber-reinforced composite material. Nor does Yanagisawa disclose that cup-shaped carbon net layers sequentially stacked one on top of the other enhance compressive strength of carbon fiber-reinforced composite materials.

One of ordinary skill in the art at the time of the invention would not have been motivated to combine the teachings of Yanagisawa with teachings of Ranta. Therefore, claim 1 is not obvious over Ranta in view of Yanagisawa.

C. Unexpected Results

Applicants respectfully submit that "carbon nanofibers hav[ing] a structure in which cup-shaped carbon net layers are sequentially stacked one on top of the other" produce unexpected results.

First, the carbon nanofibers of the present invention, having a structure in which cup-shaped carbon net layers are sequentially stacked one on top of the other, achieve completely even dispersion of the carbon nanotubes in the epoxy. Attachment 1 is a Transmission Electron Microscope photograph which demonstrates dispersion states of two specimens in epoxy resins in which Fig. (a) shows conventional "multi-walled carbon nanotubes" and Fig. (b) shows the carbon nanofibers having a structure in which cup-shaped carbon net layers are sequentially stacked one on top of the other. As can be seen in the conventional method shown in Fig. (a), some agglomerates are formed and there is uneven dispersion of the carbon nanotubes. By contrast, the carbon nanofibers of the present invention shown in Fig. (b) have completely even dispersion of the carbon nanotubes in the epoxy.

Second, the cup-shaped layer-type carbon nanofibers of the present invention also can be well impregnated in the carbon fibers. Since the gap between carbon fibers is so narrow, between 2 and 5 μm, generally it is very difficult to impregnate carbon nanofibers in the gaps of carbon fibers. However, the cup-shaped layer-type carbon nanofibers of the present invention can be well impregnated in carbon fibers because the carbon nanotubes of the present invention have good dispersion in the resin and their length can easily be adjusted due to the cup-shaped

layer so that the carbon nanotubes can intrude into the gap between the carbon fibers. Attachment 2 is a Scanning Electron Microscope photograph showing the state of impregnation of the carbon nanotubes in carbon fibers of the present invention. Attachment 2 shows good impregnation of the carbon nanofibers in carbon fibers.

By contrast, conventional carbon nanofibers could not be dispersed in the epoxy resin and could not achieve impregnation in the carbon fibers. For this reason, the test was stopped for the conventional carbon nanofibers and no SEM photographs were taken.

Third, the combination of the cup-shaped layer-type carbon nanofibers and the fiber-reinforced composite material in the present invention has remarkably enhanced strength of delamination, compressive strength and bending strength as demonstrated in Fig. 3 of the present application.

A conventional fiber reinforced composite material has extremely high tensile strength in the fibrous direction, but has the unsolved problem that it has inferior strength of delamination and compression. At present, actual examples of composite materials where the compressive strength was highly increased have not been obtained.

The cup-shaped layer-type carbon nanofibers of the present invention achieve completely even dispersion, achieve good impregnation in the carbon fibers, and achieve remarkably enhanced strength of delamination, compressive strength, and bending strength. Therefore, the carbon nanofiber-dispersed resin fiber-reinforced composite material of the present invention achieves unexpected results over conventional fiber reinforced composite materials.

In view of the aforementioned amendments and accompanying remarks, Applicants submit that that the claims, as herein amended, are in condition for allowance. Applicants request such action at an early date.

If the Examiner believes that this application is not now in condition for allowance, the Examiner is requested to contact Applicants' undersigned attorney to arrange for an interview to expedite the disposition of this case.

If this paper is not timely filed, Applicants respectfully petition for an appropriate extension of time. The fees for such an extension or any other fees that may be due with respect to this paper may be charged to Deposit Account No. 50-2866.

Respectfully submitted,
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Enclosures: Attachment 1: The Dispersion States in the Epoxy
Attachment 2: The State of Impregnation of Carbon Nanotubes

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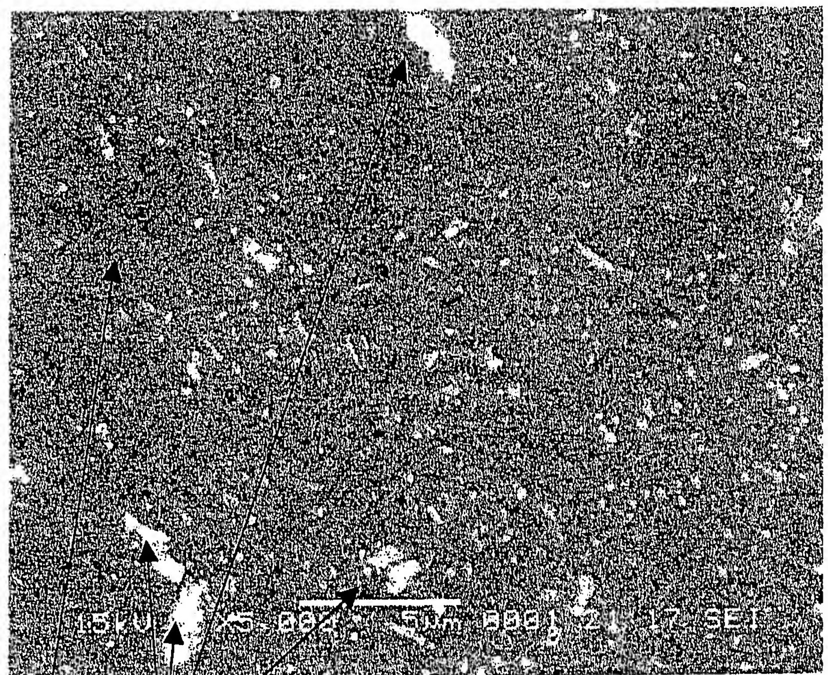
The dispersion states in the epoxy

(a) conventional multi-walled carbon nanotubes (8%)

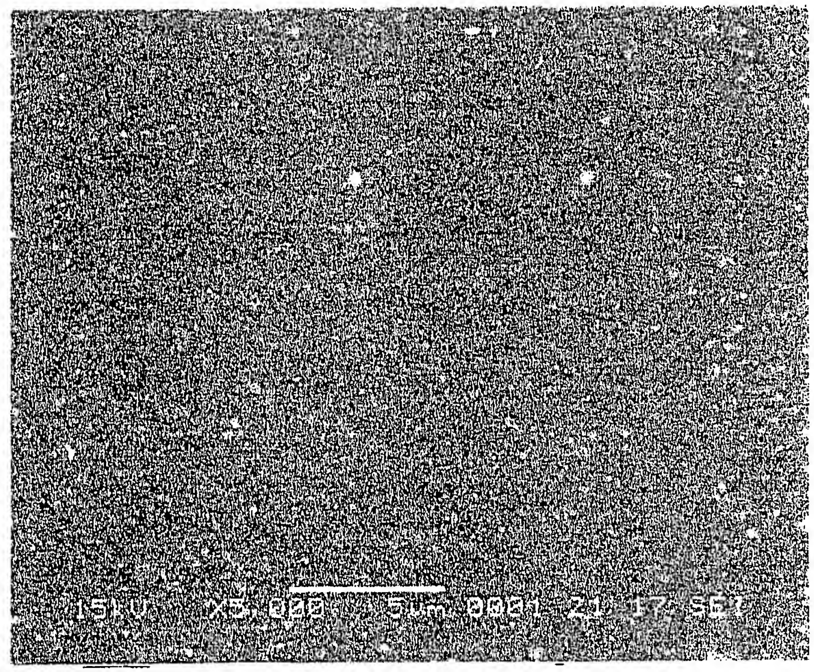


Some agglomerates and uneven dispersion are observed.

agglomerates

none of nanofibers

(b) cup-shaped carbon nanofibers (8%)



The carbon nanofibers are uniformly dispersed in the epoxy.

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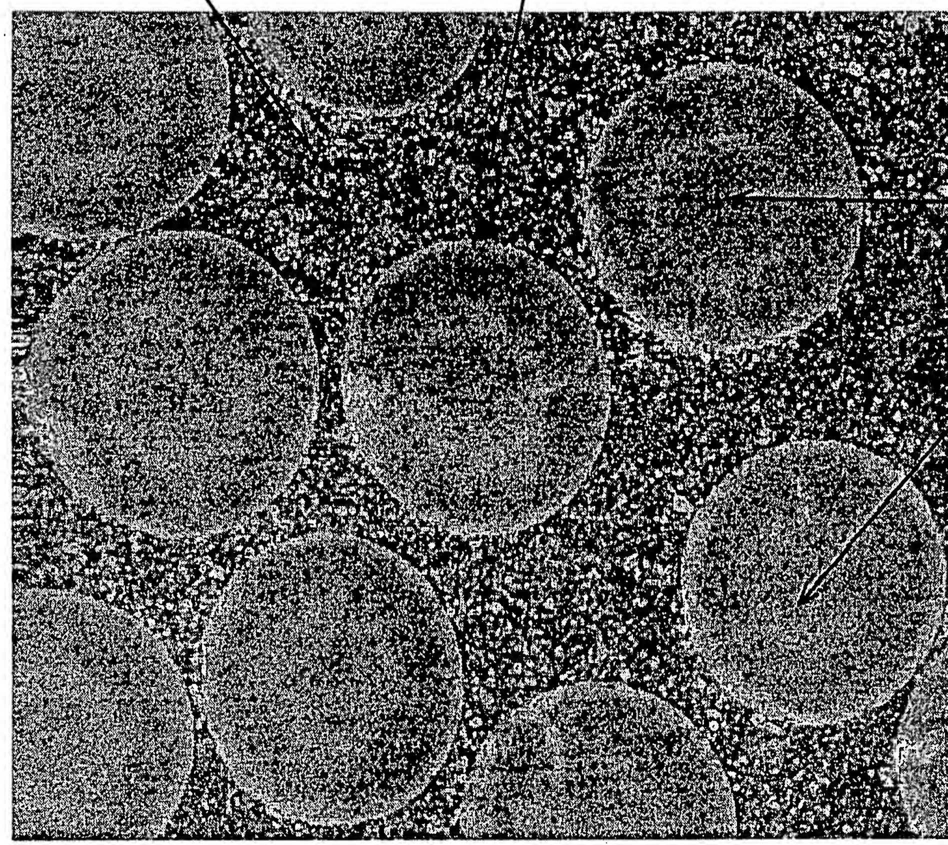

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